APPENDIX H

INDUSTRIAL TECHNOLOGIES PROGRAM

INPUTS FOR

FY 2008 BENEFITS ESTIMATES

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Program Summary

The Industrial Technologies Program (ITP) will continue its mission of supporting the development of energy efficient, clean manufacturing technologies by partnering with the industrial sector. ITP has embraced leaner and more agile operating practices to lower industrial energy intensity with reduced resources. By analyzing opportunities, coordinating with other EERE programs, and dynamically refocusing activities, ITP will leverage the current FY 2008 budget request of approximately $45.998 million to boost energy efficiency in a sector whose current energy use is approximately 33 quadrillion Btu, one-third of the U.S. total. The annual cost of U.S. industrial energy consumption is about $300 billion (at 2005 prices), and therefore each one percent reduction in this energy demand achieved through efficiency improvements will save the Nation about $3 billion annually.

Evolving energy, environmental, and economic challenges facing U.S. industry present ITP with abundant opportunities and options for R&D focus. At the same time, resource constraints and fiscal prudence call for more sharply focused strategies that will achieve maximum measurable results for the nation. In defining our R&D investment strategies, a broad range of relevant information and trends are taken into account. These include:

- Analyses of technology impacts on energy use during basic materials manufacturing, downstream fabrication, forming and assembly, product end use, and recycling and recovery of energy and materials
- Evolving business patterns and structural shifts in U.S. manufacturing
- Volatility in supply and price of fuels and feedstocks, especially petroleum and natural gas
- Maintaining technological leadership in global markets
- Growing worldwide concern about climate change impacts
- Significance of profits, jobs, and competitiveness to U.S. economic security
- Movement overseas of manufacturing and critical capital equipment suppliers

To achieve national goals and benefit industries and communities across the nation, ITP plays a key role in guiding research by developing more energy-efficient technologies. Technologies that improve energy efficiency typically deliver associated benefits in reduced emissions, decreased waste by-products, improved competitiveness, and (potentially) enhanced product quality. ITP seeks to strategically maximize and develop better metrics for capturing the aggregate benefit of increased industrial energy efficiency to American society.

In view of the existing challenges, trends, opportunities, and resources, ITP plans to re-examine some aspects of its technology R&D portfolio such as:

- Research alternatives for natural gas to reduce vulnerability to critical supply and price volatilities, with a focus on energy-intensive industries such as chemicals and steel.
- Identification of cross-cutting research opportunities for melting, high temperature processing, fabrication, and forming of ferrous and non- ferrous metals and glass.
- Expansion of current research to address technical challenges in energy conversion systems (e.g., Super Boiler, waste heat recovery), separations (e.g., advanced drying), and alternative chemical reactions.

- Exploring next generation manufacturing concepts to respond to strategic needs and to produce transformational outcomes that enhance U.S. technological leadership.

Significant Changes from Previous Analysis

The budget request calls for a transition in ITP's program planning unit structure beginning in FY 2008 from one focused on R&D addressed to (1) specific vision industries of the future, (2) cross-cutting R&D, and (3) technical assistance (including Industrial Assessment Centers (IAC) and Best Practices) to a more explicitly cross-cutting structure with three new R&D program components:

- Energy-intensive Process R&D,
- Fuel and Feedstock Flexibility, and
- Interagency Manufacturing R&D

and two new technical assistance program components:

- Voluntary Industrial Partnerships and
- State Collaboratives.

ITP will allocate new FY 2008 projects among these program components, and will phase out funding for the industry-specific planning unit projects as each project is completed. It is expected that transition to the new cross-cutting planning structure will be completed within two to three years. However, GPRA08 benefits are necessarily based on analysis of the FY 2007 program portfolio because the specific content of the FY 2008 portfolio is as yet unknown.

The Baseline ("without DOE RD3") Case

AEO2006 projects industrial energy consumption to grow by nearly 23 percent between 2006 and 2030, despite continuation of the historical trends toward lower industrial energy intensity. Between 1980 and 2004, aggregate industrial energy intensity, measured as industrial delivered energy per dollar of GDP, declined by 3.0 percent per year, and industrial delivered energy per dollar of industrial value of shipments declined by 1.6 percent per year. These trends were caused by a greater focus on energy efficiency after the energy price shocks of the 1970s and 1980s and a reduction in the share of manufacturing activity accounted for by the most energy-intensive industries. In the *AEO2006* reference case, these trends continue at a slower pace through 2030. Industrial energy use per dollar of GDP declines by 2.1 percent per year on average from 2004 through 2030, and energy use per dollar of industrial value of shipments declines by 1.2 percent per year. The expected rates of decline in industrial energy intensity are less rapid than those from 1980 to 2004, in part because the non-manufacturing portion of industrial value of shipments (agriculture, mining, and construction) grows more slowly than the manufacturing portion, which includes the more energy-intensive industrial sectors. Continued baseline improvement in energy productivity was accounted for in the ITP methodology. ITP's methodology essentially subtracts a fixed "next best" baseline technology from a fixed advanced technology to obtain unit technology savings. The conventional technology with which each new technology was compared was generally the best currently available technology—not a projected technology that might or might not exist at the time of market introduction or the average technology in current use. The energy savings of a new technology due to government R&D were determined by the number of years the technology's

market introduction is accelerated as a result of ITP funding. Only the difference relative to the baseline case, i.e., the slice of net energy savings attributable to the program's effort, was counted as benefits. In this way, the methodology incorporated an assumption (consistent with NEMS-GPRA 08) that the energy intensity of industrial production will steadily improve, and that Federal co-funding only temporarily accelerate the rate of improvement in the targeted production activities. Acceleration periods ranged from 3 to 38 years, with an average of approximately 8 years.

While the historic industry-level rate of improvement in production energy intensity tends to follow fairly smooth curves of monotonic improvement, it is very difficult to predict the future energy performance of as-yet unidentified new technologies to perform specific functions. In addition, the best currently available technology is often not yet widely adopted in the market, so that when the ITP technology enters the market, the current best-available technology may still represent the next-best decision alternative for many cases. As a result, the use of current best available technology as a comparison point for new technology investment may have the tendency to understate rather than overstate the impact of a new technology savings. Of still greater significance, taking credit for only that slice of savings due to the presumed acceleration of the new technology's market introduction date was intended to eliminate any overestimation of savings due to the underlying rate of capital turnover-driven technology improvement.

Due to differences in the analytical approach of the NEMS-GPRA08 model and MARKAL GPRA08 model and ITP's bottom-up energy-savings projection methodology, it was not possible to definitively match NEMS's base-case assumptions with the implicit base case in the GPRA study. NEMS-GPRA08 addresses the entire industry group in a top-down manner, assigning energy intensities to a comprehensive set of activities to project total industry energy use under alternative assumptions. In contrast, the bottom-up ITP GPRA study specified the unit energy savings of a particular set of advanced technologies, each in comparison to a best-available commercial technology alternative. ITP GPRA benefits consisted of savings resulting from the acceleration of market entry for each technology. The two approaches are not inconsistent. The NEMS-GPRA08 model and the MARKAL-GPRA08 model provide the context for benefit measurement in the overall economic framework.

Target Market Description

As stated earlier, the industrial sector currently uses one-third of all U.S. energy supplies. This energy is consumed in processes and activities operating at substantially less than theoretical maximum efficiencies, leading to many significant technological and market transformational opportunities to reduce the energy intensity of industrial production. Many technological opportunities are intrinsically related to non-energy productivity improvements such as reduced capital and operating costs, increased plant production, reduced in-plant scrap rates, and reduced pollution control costs. Another feature of the markets for energy-efficient industrial production technology is that intense global competition is the norm, and U.S. technological leadership in these major production equipment supply chains is vital to our international competitiveness and economic success.

Advanced industrial energy efficiency technologies under development with program support will enter a variety of specialized markets, including those for production equipment, plant

energy conversion and distribution, heat recovery, process control, and waste-reduction equipment. These markets vary in many ways, including their size and growth rate, degree of specialization, the scale and lifetime of unit capital investments, U.S. technological competitiveness, and the degree to which non-energy considerations such as productivity are important in investment decisions.

The production of industrial commodity products such as paper, steel, aluminum, chemicals, and glass is very capital intensive, and involves a large number of specialized production methods that have evolved over many decades. This diversity leads to complex technology and market characterizations, and has led to a relatively large number of technology R&D initiatives being required to address the principal targets of opportunity. In FY 2008, ITP will begin to re-focus its R&D support toward cross-cutting, multiple-application, enabling technologies such as advanced materials and combustion science, and on cross-cutting technology platforms such as advanced distillation and Super Boiler technologies. The pace of improvements in energy intensity in these important production applications is limited by the R&D resources addressing technical challenges, the economic performance of the industries involved, and the rate of turnover of capital-intensive plant and equipment.

Underlying fuel prices, the electricity generation and distribution fuel mix and heat rates, and sector economic growth rates — used in the NEMS-GPRA08 runs that produced the ultimate results from ITP's energy-savings inputs—were chosen to be consistent with the reference case in the Department of Energy's (DOE/EIA) *Annual Energy Outlook 2006*. ITP's off-line calculation of fuel and electricity savings for individual projects and program-element activities did not refer explicitly to macro-baseline projection of energy consumption quantities; rather, a unique market growth rate was specified in each of the Technology Impact Projections Model[1] runs performed for GPRA08. This permitted the analysts to differentiate among highly varied market outlooks for specific energy using activities within various industry groups. Except for several chemicals industry market targets with short-term growth rates of more than 5 percent, the range of these annual market growth rates was from -1 to 5 percent, with an average close to 2.4 percent. By comparison, short-term AEO 2006 annual growth rates for highly aggregated energy intensive industries ranged from 0.7 percent to 2.9 percent and averaged 1.6 percent. The wider range of short-term growth rates specified for the less aggregated and selectively growing energy use activities targeted by the model runs seems logically consistent.

The target market for each of R&D technologies included in the ITP study was described qualitatively and quantitatively in a spreadsheet-based Technology Impact Projections Model run

[1] Fifty-five Technology Impact Projections Model runs performed in the GPRA08 off-line benefits study are documented in "GPRA08 Quality Metrics – Methodology and Results," draft, June 2006, by Energetics Incorporated. The Technology Impacts Model is described in the same document. In summary, this model is a system of spreadsheets designed to calculate (1) the unit differences between the new and existing technology in fuels and electricity use during one unit's operating year, (2) the size and projected growth of the new technology market, (3) the schedule of development milestones leading to commercial introduction of the new technology assuming a successful DOE R&D program, (4) the "acceleration period", or number of years by which the commercial introduction is advanced by the DOE R&D program, (5) the market penetration curve characterizing the technology's likely path towards market saturation assuming commercial success, and (6) projected national energy savings impacts due to the acceleration of the new technology by the DOE program.

(summarized in Table H-6). The technologies were grouped based on common production activity Impact Targets. This specification of target markets was done to facilitate the identification of potentially overlapping markets. Where potentially overlapping markets were found, either the market was split between the two competing technologies or only one spreadsheet model run was used to represent both technologies.

Markets were initially defined in terms of the total number of technology units potentially in use at the year of introduction. Next, this number was reduced to the fraction of those units considered technically and economically accessible. The number of technology units was further reduced to the likely achievable technology market share accessible to the technology as compared to other advanced technologies. Finally, the target market was reduced to the savings potential attributable to the program. The market size was adjusted annually by the spreadsheet logic, based on the specified annual percentage market growth rate.

Baseline Adjustments to the AEO 2006 Reference Case

ITP did not make any baseline adjustments to the AEO 2006 reference case because no redundancies between the program energy savings and the assumptions of AEO 2006 were identified.

Representation of Program-Relevant Technologies in the AEO Reference Case

The AEO Reference Case describes broad structural and technological baseline trends underway in many of the energy-intensive industries that could affect the likely impact of the advanced technologies analyzed for GPRA08. However, the off-line ITP GPRA08 analysis took into account these trends, such as the trend towards electric arc furnaces in the steel industry and the trend towards secondary smelting of aluminum, as well as other market-related developments in the characterization of both the new technology and the next-best conventional technologies, and also in the sizes and growth rates assigned to future markets for each ITP technology.

Reference Case baseline technology improvements can be seen principally as the effect of continual replacement of retired capital equipment with newer, more efficient production equipment. The program accelerates the availability of the most advanced energy-using equipment, temporarily enlarging and improving the mix of technology options available to industrial decision-makers when certain energy-intensive equipment is purchased. Thus, the AEO Reference Case can be assumed to include best-available current technology, absent the acceleration of this technology's availability due to the Federal program.

Removing Effects of Program Activities

The AEO Reference Case does not explicitly exclude the effects of historically funded programs such as ITP. Nevertheless, ITP's off-line benefits assessment methodology did not require the construction of a "non-program" baseline because the methodology counted only the slice of net energy savings for each industry associated with the acceleration of certain advanced technologies' availability.

Other Program-Relevant Adjustments to AEO Reference Case

ITP did not make any adjustments to the AEO Reference Case.

Program Outputs

The logic model is presented in Figure H-1. For this purpose, program activities can be divided into two main areas: R&D and Technical Assistance. R&D milestones are project specific and range from basic research advances to in-plant demonstrations. Technical Assistance milestones include information dissemination and the formation of new partnerships. R&D outputs are focused on energy efficiency and performance improvements. Technical assistance outputs can be quantified in terms of audits completed and plants impacted. External factors such as fuel commodity prices and government regulations impact interim outcomes, such as commercialization and market penetration.

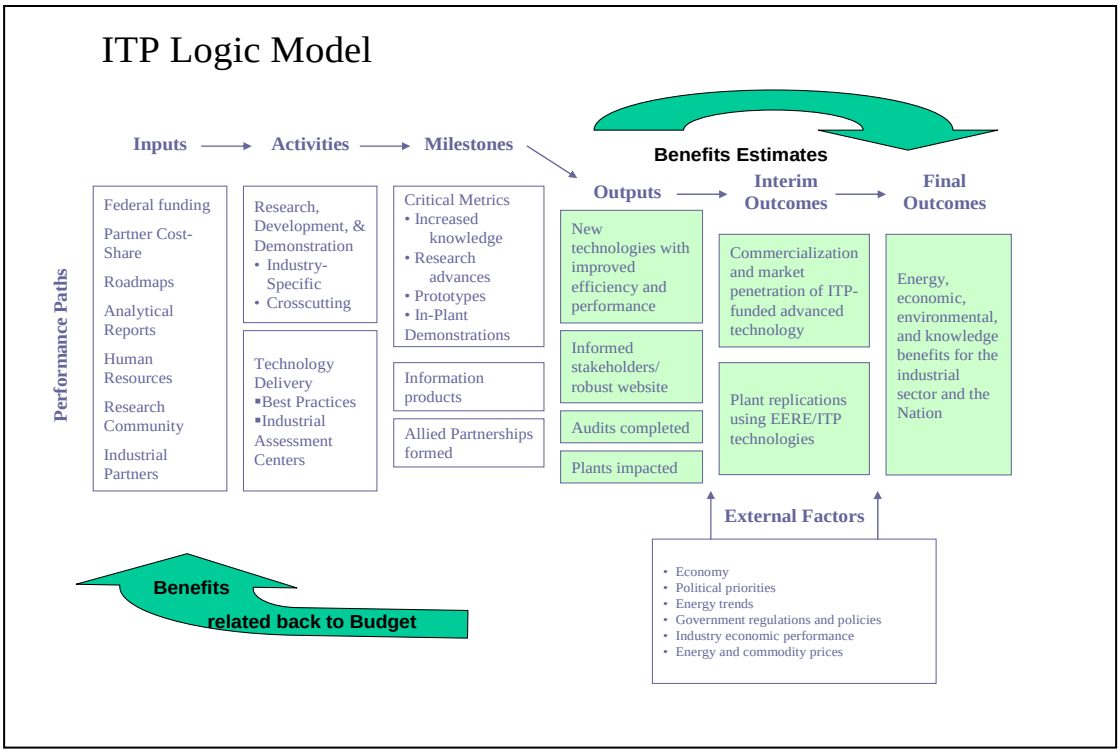

Figure H-1: ITP Logic Model

Assumed Budget Projections

Table H-1 shows the funding scenario that is currently anticipated for the Industrial Technologies Program over the next five years. The program will use the convening power of government to form working groups for future industrial cooperation in new R&D program components: (i) Energy-intensive Process R&D, (ii) Interagency Manufacturing R&D, and (iii) Industrial Fuels and Feedstock Flexibility. Work in these areas will begin in FY 2008. Additionally, two new Technical Assistance program components, (i) Voluntary Partnerships and (ii) State Collaboratives, will begin in FY 2008.

Priorities:

- The program is shifting its focus from more industry-specific R&D to broader crosscutting and transformational initiatives with higher potential impacts.

Reallocations to Support EERE Priorities:

- The program shift will provide the foundation for the next generation of manufacturing processes to dramatically improve the energy efficiency and environmental performance of the energy intensive and waste-intensive industries.
- The Technical Assistance portion of the program will explore better technology validation and delivery strategies to increase the adoption of energy-efficiency technologies and operating practices. The Best Practices activity will continue to conduct energy savings assessments to reduce manufacturing plant natural gas consumption in support of the Secretary of Energy's "Easy Ways to Save Energy" campaign.

Table H-1: ITP Funding Scenario ($ thousands)

FY2006 Appropriation	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
56,855	45,563	45,998	45,998	45,998	45,998

Description of Key Activities

In addition to the three new R&D program components (Energy-intensive Process R&D, Interagency Manufacturing R&D, and Industrial Fuels and Feedstock Flexibility) and two new non-R&D components (Voluntary Industrial Partnerships and State Collaborative Assistance), ITP will begin to bring to completion its activities begun under the previous program structure. The specific content of these new program components in FY 2008 is not known at this time. For the purposes of the FY 2008 GPRA study, (a) Energy-intensive Process R&D, (b) Interagency Manufacturing R&D, and (c) Fuel and Feedstock Flexibility planning units were assumed to be similar in their results to the previous Industries of the Future (IOF) Specific and Crosscutting R&D program components, and (a) Voluntary Industrial Partnerships and (b) State Collaborative planning units were assumed to be similar in results to the previous Technical Assistance program component.

R&D Activities

ITP's FY 2008 off-line GPRA study used the FY 2007 portfolio as a surrogate for the as-yet unknown FY 2008 projects, assuming that the results will not vary too greatly when adjusted for the differences in funding magnitude. In FY 2007, ITP was oriented around R&D in the following industries:

- Aluminum
- Chemicals
- Forest Products
- Metal Casting
- Steel

ITP also supported R&D in several Crosscutting Technologies that are used extensively throughout industry, including:

- Combustion
- Materials
- Sensors and Automation

Projects underway in these planning units will be continued toward completion in FY 2008, and new R&D projects, as-yet unknown but focused on the new EERE priorities, will be initiated in the following subprogram areas:

- Energy-intensive Process R&D
- Interagency Manufacturing R&D
- Fuel and Feedstock Flexibility

Non-R&D Activities

In FY 2007, ITP conducted non-R&D activities under the Technical Assistance subprogram:

- Industrial Assessment Centers
- Best Practices

Ongoing work in these planning units will be continued, and two new subprogram areas will be added, which will also undertake additional, as-yet unknown projects focused on EERE priorities:

- Voluntary Industrial Partnerships
- State Collaborative Assistance

Milestones

The program milestones for the Industrial Technologies Program are presented in Table H-2. These milestones extend the FY 2007 program structure with significant milestones from FY 2008 through FY 2011. No milestones are yet known for the new program components.

Table H-2: Program Milestones 2008-2011

Year	FY 2007 Planning Unit	Description
FY 2008	Aluminum	Complete the final design of a 7,000 lb/hr production ITM, with 50% energy savings potential.
FY 2008	Chemicals	Install a pilot unit and conduct field test for a natural gas removal technology that will replace existing cryogenic process and recover 70% of C2.
FY 2008	Forest Products	Commercial availability of underwater sparker that improves the efficiency of contaminant removal in the paper recycling process by 10-15%.
FY 2008	Metal Casting	Establish new melting practices with 10% energy savings in producing steel castings.
FY 2008	Steel	Complete laboratory scale development of scale free reheat furnace. Confirm reheat furnace environment can be tailored to eliminate formation of difficult to remove iron oxide scale (current processes 1% to 2.5% of product weight) to a negligible surface amount.
FY 2008	Combustion	Complete development of liquid fuel capability for >94% efficiency 300 hp firetube boiler.
FY 2008	Materials	Demonstrate new refractory materials production and applications techniques for refractory systems with 20% better thermal efficiencies and 100% better life spans than conventional refractories for industrial processes.
FY 2008	Sensors/ Automation	Demonstrate 80% steel bar surface defect reduction.
FY 2008	Best Practices	Initiate EPACT section 106 voluntary industry commitments supporting corporate energy management.
FY 2008	IACs	2.7 TBtu/yr total new Assessment Savings.
FY 2009	Aluminum	Install a production ITM at an Aleris facility, with 50% energy savings.
FY 2009	Chemicals	Demonstrate a micro channel reaction oxy-deyhdrogenation technology that will achieve 82% selectivity for production of olefins.
FY 2009	Forest Products	Successful demonstration at mill scale of a pulping technology that can reduce the natural gas demand for lime kiln firing by 10%.
FY 2009	Metal Casting	Complete the development of smart coatings to extend die life by over 10%.
FY 2009	Steel	(1) Make quality iron nodules at least 100 degrees C below the current process temperature of 1500 degrees C . (2) control furnace atmosphere and use Western coals as the reductant; resulting also in reduced use of natural gas.
FY 2009	Combustion	Conclude first phase of development of >94% efficiency watertube boilers capable of 1500 deg and 1500 psi steam and select one project to carry forward to field trials.
FY 2009	Materials	Validate performance of a sensing element in a simulated service environment for application in closed-loop, feedback control of industrial combustion with fuel savings of up to 24 trillion Btu/yr.
FY 2009	Sensors/ Automation	Demonstrate that inferential wireless motor monitoring is equivalent to direct measurement.
FY 2009	Best Practices	Save Energy Now Round 4 energy savings assessment application process opens.
FY 2009	IACs	2.7 TBtu/yr total new Assessment Savings.

Year	FY 2007 Planning Unit	Description
FY 2010	Aluminum	Begin the operation of a production ITM at an Aleris facility, with 50% energy savings.
FY 2010	Chemicals	Complete the development of a microchannel distillation technology that will revolutionize distillation technology in general and improve the overall distillation column efficiency by over 40%.
FY 2010	Forest Products	Demonstrate a non-evaporative paper dewatering technology that can reduce drying steam demand by 40%.
FY 2010	Metal Casting	Complete the development of design tools for producing die castings with 10% higher strength.
FY 2010	Steel	Complete development of new iron-making process with Western coals, but without the need of using either coke or natural gas as a feedstock. Reducing coke usage from 0.340 metric ton per ton (current usage) iron to zero. Reducing natural gas usage from 4 billion joules per metric ton to zero.
FY 2010	Combustion	Conclude first field trial of >94% efficiency watertube boilers capable of 1500 deg and 1500 psi steam.
FY 2010	Materials	Demonstrate 50% improvement in friction, wear and component life for hydraulic components and cutting tools coated with ultra-hard coatings for reduction of friction losses and catastrophic shutdowns during industrial operations.
FY 2010	Sensors/ Automation	Verify ability of inferential data management system to collect and integrate different data types.
FY 2010	Best Practices	Save Energy Now Round 5 energy savings assessment application process opens.
FY 2010	IACs	2.7 TBtu/yr total new Assessment Savings.
FY 2011	Aluminum	Begin the efforts in scaling up the ITM capacity to 150,000 lb/hr, with 50% energy savings potential.
FY 2011	Chemicals	Complete development of a hybrid distillation technology that will improve the overall distillation column separation efficiency by 40%.
FY 2011	Forest Products	Develop a non-evaporative weak black liquor concentration method that can concentrate black liquor to 35% solids.
FY 2011	Metal Casting	Develop an innovative casting process with 20% improvement in productivity and energy efficiency.
FY 2011	Steel	Complete research on a steel-making process based on the concept of continuously melting, refining, alloying, and casting quality steel from scrap. Reducing energy use to 6.6 billion joules per metric ton from nearly 7.4 billion joules (good practice) from steel scrap.
FY 2011	Combustion	Conclude second field trial of >94% efficiency watertube boilers capable of 1500 deg and 1500 psi steam.
FY 2011	Materials	Demonstrate >15% energy savings and costs for aerogel –insulation of large diameter pipes for energy efficient complex steam systems
FY 2011	Sensors/ Automation	Complete creation of first inferential process control system to reduce product rejection rate by 80%
FY 2011	Best Practices	Save Energy Now Round 6 energy savings assessment application process opens
FY 2011	IACs	2.7 TBtu/yr total new Assessment Savings

Program Outputs

ITP program outputs are: completed new energy-efficient technologies, informed markets, completed plant assessments, and new partnerships. The GPRA08 study anticipates the completion of 55 advanced technologies, most of these ready for commercialization by FY 2011 (see Table H-7), IAC energy assessments at approximately 600 small and medium size plants per year, and Energy Saving Assessments at approximately 200 large plants per year.

Translating Program Outputs to Market Outcomes

Interim outcomes for ITP are the commercialization of advanced technologies in the marketplace. Final outcomes include the energy savings and other benefits resulting from operation of the new technologies in their intended markets. To understand how rapidly the potential impact of the technology may be felt, the market penetration of the technology must be projected. This is based on two estimates, the technology development and commercialization timeline, and the market penetration curve.

Technology Development & Commercialization Timeline
The commercial introduction of a technology normally occurs after a significant demonstration is completed or an operating prototype is developed, and after an adequate test and evaluation period. Other prerequisites include the readiness of the production facilities, dissemination of information, initial marketing and sales, or other "start up" factors. To capture this lengthy process, ITP analysts indicate the timeline for developing and introducing the technology into the market. This includes the years for when an initial prototype, refined prototype, and commercial prototype of the technology has or will be completed and the year when the technology will be commercially introduced. An initial prototype is the first prototype of the technology. A refined prototype represents changes to the initial prototype but not a commercially scaled-up version. A commercial prototype is the first commercial-scale version of the technology. Commercial introduction is achieved when the first unit beyond the commercial prototype is operating. Prototype and commercial introduction years should be consistent with technology development program plans. Two values for a commercial introduction year are used. One reflects when the technology is projected to be introduced if the program proceeds as expected (With-ITP case). The other reflects when the technology would have entered the market if the program had not been involved (Without-ITP case). If the technology has no chance of being commercially introduced without the program, then Year 2050 is entered for the Without-ITP case. The difference in commercial introduction years for the With-ITP and Without-ITP cases is referred to as the acceleration period. As mentioned earlier, acceleration periods vary by industry and by technology.

Market Penetration Curve (Technology Class)
New technologies normally penetrate a market following a familiar "s" curve, the lower end representing the above uncertainties overcome by "early adopters." The curve tails off at the far future where some may never adopt the new technology. Of importance is the major portion of the "s" curve where the new technology is penetrating the market

and benefits are being reaped. The rate at which technologies penetrate their markets varies significantly: penetrations of heavy industrial technologies -- with long asset lives and requiring large capital investments -- generally take place over decades, while simple (and often cheaper) process or control changes can penetrate much more rapidly. The actual penetration rate varies as a function of economic, environmental, competitive, productivity, regulatory, and other factors.

As an integral component of the ITP benefits assessment and analysis process, a large volume of actual penetration rates of past and present technologies were analyzed, normalized, and grouped into five classes based on a number of characteristics and criteria. ITP analysts completed Table H-3 for each R&D project by adding the project title in the top row and either a, b, c, d, or e in the right-hand column for those characteristics for which a judgment was possible. The overall technology market penetration curve selection was entered in the second row at the right under "Score". Note that the characteristics (rows) are relatively independent and a given technology will likely fit best in different classes for different characteristics. By examining the pattern, however, one can, based on best judgment and experience, select the most likely class (rate) at which the new technology may penetrate the market. For example, ITP analysts may deem that a few characteristics could dominate future adoption decisions to such a great extent that a particular class of penetration rate is justified. There also may be "windows of opportunity" where significant replacements of existing equipment may be expected to occur at some point in the future for other reasons. ITP analysts inserted into the spread sheet the class of penetration rate believed most likely, all things considered, and provide a narrative of the rationale for selection, if not obvious, from Table H-3.

For additional assistance, Table H-4 shows actual technologies and the class of their historical penetration rates. Comparison of the new technology, by analogy or similarity, with these examples provides additional insight into selecting the appropriate penetration rate that might be expected for the new technology. Figure H-2 graphs the historical market penetrations of industrial production technology innovations used in developing the market penetration classes.

The Technology Impact Projections Model translates the number of new technology units operating in each projection year into final energy savings outcomes by multiplying by the difference in the unit annual energy use of the new the conventional technology. As described above, each new technology is assumed to enter the market without the ITP support after the "acceleration period", so that only the net energy savings are credited to the program.

Table H-3. Selecting the Market Penetration Rate Class

Technology/project						**Score (a,b,c,d,e)**
Characteristic	**a**	**b**	**c**	**d**	**e**	
Time to saturation	5 yrs	10 yrs	20 yrs	40 yrs	>40 yrs	na
Technology factors						
Payback discretionary*	<<1 yr	<1 yr	1-3 yrs	3-5 yrs	>5 yrs	
Payback non-discretionary*	<<1 yr	<1 yr	1-2 yrs	2-3 yrs	>3 yrs	
Equipment life	<5 yrs	5-15 yrs	15-25 yrs	25-40 yrs	>40 yrs	
Equipment replacement	None	Minor	Unit operation	Plant section	Entire plant	
Impact on product quality	$$	$$	$$	$	0/-	
Impact on plant productivity	$$	$$	$$	$	0/-	
Technology experience	New to U.S. only	New to U.S. only	New to Industry	New	New	
Industry factors						
Growth (%per annum)	>5%	>5%	2-5%	1-2%	<1%	
Attitude to risk	Open	Open	Cautious	Conservative	Averse	
External factors	Forcing	Forcing	Driving	None	None	na
Gov't regulation						
Other						

* Payback is defined as capital outlay for new technology divided by savings before taxes and depreciation. In the case of Discretionary investments (i.e. replacement of existing equipment before the end of its economic life), capital outlay is total cost of new technology. In the case of Non-discretionary investments (i.e. replacement of existing equipment at the end of its economic life and new installations), capital is the capital cost of the new technology - capital cost of the current technology.

Table H-4: Examples of Industrial Innovations

Class	A	B	C	D	E
Aluminum		Treatment of used cathode liners	Strip casting, VOC incinerators		
Chemicals	New series of dehydrogenation catalyst (incremental change)	CFCs -> HCFCs, incrementally improved catalysts, membrane-based chlor-alkali	Polypropylene catalysts, solvent to water-based paints, PPE-based AN	Synthetic rubber & fibers	
Forest Products			Impulse drying, de-inking of waste newspaper	Kraft pulping, continuous paper machines	
Glass		Lubbers glass blowing, Pilkington float glass	Particulate control, regenerative melters, oxygenase in glass furnaces		
Metals Casting	New shop floor practice				
Petroleum	New series HDS catalysts	Alkylation gasoline	Thermal cracking, catalytic cracking	Residue gasification, flexicoking	
Steel	Improved EAF operating practice (e.g. modify electric/ burner heating cycle to minimize dust generation)	BOF steel making	Oxyfuel burners for steel, Level II reheat furnace controls, Continuous casting, particulate control on EAF, Hightop pressure blast furnace	Open hearth technology, EAF technology	
Other		Advanced refrigerator compressors, oxygen flash copper smelting, solvent extraction with liquid ion exchange	Fluegas desulfurization (coal-fired utilities), low NO_x industrial burners, industrial gas turbines, ore beneficiation		Dry-kiln cement, industrial ceramic recuperators Industrial heat pumps

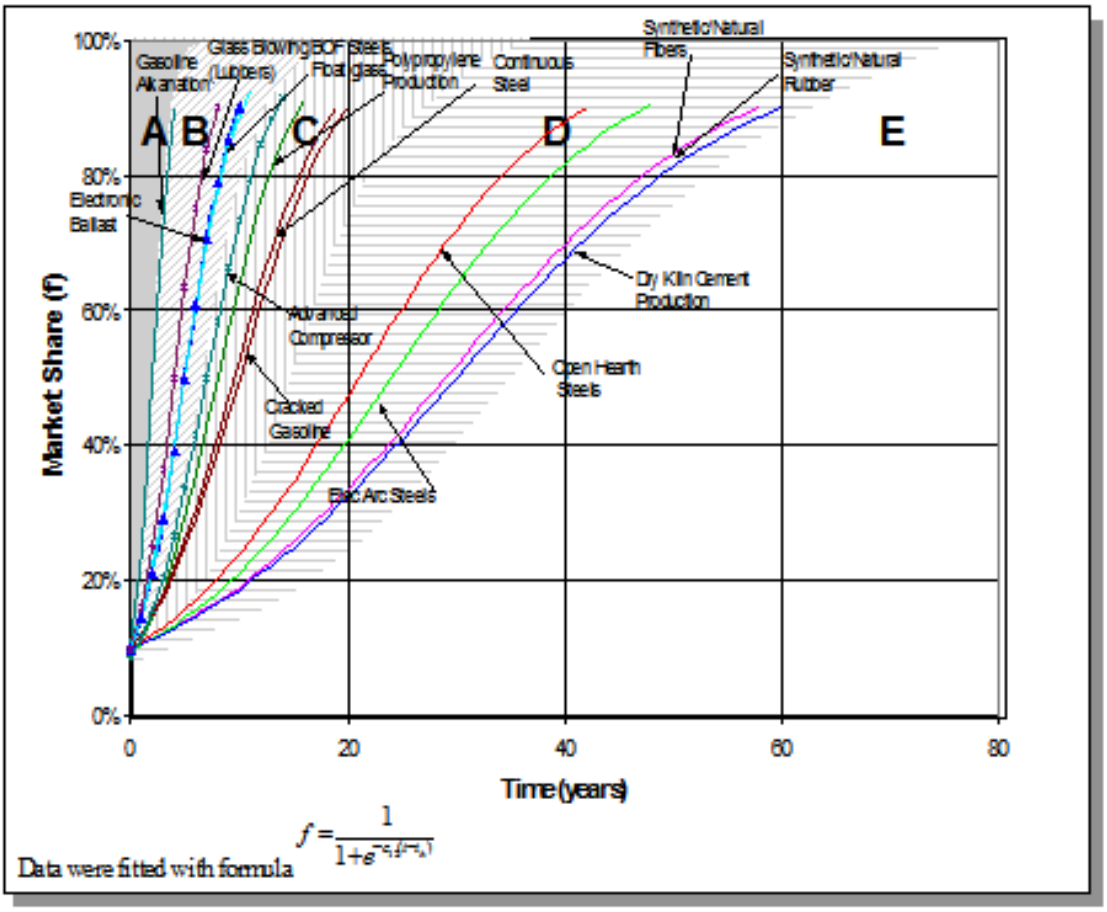

Figure H-2: Market Penetration Rate Classes

Key Factors in Shaping Market Adoption of EERE Technologies

Price

ITP methodology places little emphasis on cost-based estimation of market penetration, because useful cost information on industrial technologies in the R&D stage of development is, in nearly all cases, not available. Instead, relative costs in the form of the expected payback period, were one of numerous market-driving factors in matching the market-penetration schedule with each innovative technology (see previous section). These market-penetration schedules are typical of historical industrial-sector technology innovations, whose characteristic payback period, scale, equipment lifetime, impact on product quality, relevant experience level, market growth rate, attitude to risk, and other factors were matched to each innovative technology to select the best market-penetration schedule.

Non-price Factors

- Key Consumer Preferences/Values.

Several consumer preference/value issues were incorporated in the ITP market-penetration curve selection technique. These include factors such as technology scale, equipment lifetime, impact on product quality, etc. listed above.

- Manufacturing Factors.

The benefits-estimation approach requested the analyst to estimate the year in which the technology is expected to be successfully developed at the successive stages of (1) completion of initial R&D, (2) initial system prototype, (3) refined prototype, (4) commercial prototype, and finally (5) commercial introduction, given the push provided by the ITP program support. These estimates were documented as part of each spreadsheet model run.

- Policy Factors.

In the great majority of cases, no policy factors were considered significant to the market introduction and acceptance of ITP technologies. However, for cases where a regulation or other policy will drive the market to accept a new technology solution, the market-penetration curve selection procedure was set up to accept this information and allow it to play a role in the analysis. Any such influence was discussed in documentation provided in the spreadsheet model run. No new policies were assumed for the GPRA08 runs.

Immediate Outputs

ITP outputs, as shown in Figure H-2, include completed new technologies with improved efficiency and performance, informed stakeholders, and energy assessments and audits completed. No immediate outcomes are included in the logic chain.

Interim Outcomes

Interim outcomes include the commercialization and market penetration of ITP-funded advanced technologies and plant replications using EERE/ITP technologies.

Final Outcomes (Benefits)

Final outcomes are the energy savings and other benefits for the industrial sector and the Nation associated with the support provided by the Program. ITP's off-line study reported here computed only energy savings, which were subsequently used by NEMS and MARKAL analysts to produce the full complement of integrated energy-related environmental and economic benefits required for GPRA.

As discussed above, energy savings for R&D projects were calculated in GPRA08 using the Technology Impact Projections Model, a spreadsheet system with which each of 55 advanced technologies included in the FY 2007 portfolio was analyzed (see Table H-6) according to the methodology described here and summed to produce results which were extended to represent the R&D component of the ITP Program. The results for Industries of the Future (IOF) planning units were extended to the new FY 2008 R&D program components using the same average energy savings per dollar of budget request.

The Industrial Assessment Centers and BestPractices non-R&D activities were assessed based on retrospective analysis of performance data accumulated over a period of years. Quality Metrics for these planning units assume that continuation of these activities will result in benefits that are proportional to documented experience at historical budget levels. These analyses assume no continuing contributions from prior program expenditures, but only assume that future expenditures will produce results proportionate to those reported for past expenditures. The results for IAC and Best Practices planning units were extended to the new non-R&D program components using the same average energy savings per dollar of budget request.

The Industrial Assessment Center (IAC) activity within the Industrial Technologies Program (ITP) has been successfully generating energy savings for over 25 years. Twenty-six Industrial Assessment Centers located within engineering departments at top universities across the U.S. conduct comprehensive energy assessments for small- and medium-sized manufacturers and train the future workforce of energy engineers. The IAC generates savings through three main delivery channels: 1) IAC energy assessments, 2) assessments conducted by members of the IAC alumni and 3) the popular IAC database website which includes data from over 13,000 assessments as well as self-assessment manuals and similar resources.

Projected output and outcome performance estimates rely upon information from the IAC assessment database, the IAC student registry, and evaluation work conducted by Oak Ridge National Laboratory (ORNL). The projections assume a flat budget based on the budget request for FY 2007. The IAC database documents savings recommendations and implementation history for plant assessments conducted over a 25-year period, covering more than 13,000 assessments and nearly 100,000 savings recommendations.[2]

The IAC student registry, established more recently in FY 2001, tracks the progress of students from their starting date through their departure. Finally, ORNL evaluations have studied the longer-term effects of plant assessments, career paths of IAC alumni and the savings potential of web-based materials offered by the IAC. The calculation of energy savings for the IAC activity is summarized in Table H-7.

The Industrial Technologies Program's (ITP) BestPractices activity is designed to provide industrial plant managers with information to evaluate and implement opportunities for improving the efficiency of energy-intensive systems within their production facilities. These energy-intensive systems include those with motors and drives, pumps, air compressors, steam, fans and process heat. Estimates of energy savings outcome were developed by Oak Ridge National Laboratory (ORNL) and are based on preliminary results from FY2005 activities and early results from FY2006 Energy Saving Assessments (ESAs)[3]. These estimates reflect a focus on key participants and four main delivery channels of BestPractices.

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[2] The IAC assessment database is located at www.iac.rutgers.edu.

[3] Data used in the GPRA analysis reflect the most recent data available at the time of the GPRA analysis and does not reflect finalized FY 2005 participant levels from the BestPractice Tracking Sytem (BPTS), nor does it reflect all programmatic changes implemented in response to the Save Energy Now Secretarial Initiative. Therefore, outcomes for FY 2005 activities documented in reports published after this GPRA08 analysis will include a more accurate representation of FY 2005 performance.

BestPractices relies upon four main delivery channels to disseminate technical information to a target audience of manufacturing establishments with high annual energy consumption (greater than $3 million per year). Considerable numbers of medium-sized manufacturers (with energy costs under $3 million per year) also participate in the program. The main delivery channels include: 1) Energy Saving Assessments (ESAs), 2) End-User training, 3) software, and 4) specialists qualified by BestPractices to address industrial applications of energy-intensive steam, fan, pumping, compressed air and process heating systems.

BestPractices output performance in the four main delivery channels is measured in terms of the number of unique domestic plants represented within the initial reach and the number of unique plants that are believed to take action to implement energy projects. The initial reach represents the total number of participating plants identified in each of the BestPractices delivery channels. The BP Tracking System[4] provides data on initial reach and participant affiliation, including identification of unique plants. The number of unique plants is then scaled back using data from the literature or from participant feedback to estimate the number of unique, U.S. plants taking action due to this information dissemination.

The basic methodology for estimating the energy outcome of BestPractices is a combination of averaged energy savings reported by ESAs and calculated savings for training, software use and Qualified Specialists. Energy benefits generated by ESAs are based on engineering estimates of savings identified in assessment reports and plant consumption levels. Savings associated with unique U.S-based plants that implement projects following interaction with Qualified Specialists, or by participation in training or use of software are estimated using historical assessment data from BestPractices and the Industrial Assessment Centers (IAC). The calculation of energy savings for BestPractices is summarized in Table H-8.

The methodology used to calculate the benefits of the IAC and Best Practices programs is described in detail in Energetics Incorporated, "GPRA08 Quality Metrics – Methodology and Results," draft, June 2006.

[1]The BP Tracking System contains general participant information for all annual BestPractices activities. Data from FY 2005 activities recorded in the BP Tracking System was used for the preparation of the GPRA 2008 report. This information is used to categorize participants as unique plants and to eliminate over counting for those that take part in multiple activities. Additionally, only participants representing domestically located, unique plants are used in the projected savings estimates.

Summary of Inputs

Final results of the ITP off-line benefits assessment are presented in Table H-5. These results were normalized to the FY 2008 budget request: (a) for all R&D programs, based upon 55 Technology Impact Projections Model runs for technologies in the FY 2007 portfolio, and (b) for all Technical Assistance programs, based upon the historical performance-based analyses of the FY 2007 IAC and Best Practices planning units. Table H-6 summarizes the Technology Impact Projections Model runs, and Tables H-7 and H8 summarize the calculation of IAC and Best Practices energy savings, respectively.

Table H-5: GPRA08 ITP Total Energy Savings

Impact By Year	2008	2009	2010	2015	2020	2025	2030	2040	2050
ANNUAL SAVINGS									
Energy Metrics									
Total primary energy displaced (trillion Btu)	35.74	109.55	192.31	720.66	1525.82	2336.52	2086.07	1321.85	933.49
Direct electricity displaced (billion kWh)	0.92	2.83	5.71	22.84	44.04	54.78	50.70	51.17	48.04
Direct natural gas displaced (bcf)	19.14	51.66	93.96	369.63	809.49	1383.68	1171.59	572.27	341.46
Direct petroleum displaced (million barrels)	0.43	0.98	1.71	7.21	14.67	13.80	8.06	6.21	4.98
Direct coal displaced (million short tons)	0.13	0.85	1.26	3.31	6.01	10.01	13.46	8.18	3.15
Feedstock energy displaced (trillion BTU)	1.48	2.48	4.55	30.75	109.36	135.32	77.91	56.49	67.49
Biomass energy displaced (trillion BTU)	0.00	0.00	0.51	1.46	3.95	11.83	21.74	25.50	21.73
Waste energy displaced (trillion BTU)	0.00	0.12	0.19	1.50	6.21	5.95	1.49	0.03	0.00
Other energy displaced (trillion Btu)	0.25	0.53	1.05	4.89	12.35	18.19	20.72	21.50	12.76

Table H-6: Summary of 55 Technology Impact Projections Model Runs for GPRA08

Impact Target	Project	Energy Savings (Tbtu) 2010	Energy Savings (TBtu) 2020	Energy Savings (TBtu) 2030	Year of Intro / Market Selector / Acceleration Period
Efficient Aluminum Melting Technologies	Energy Efficient Melting and Direct Delivery of High Quality Molten Aluminum (Energy Efficient Isothermal Melting of Aluminum) CPS Agreement #13128	0.4	12.7	11.0	2008/b/12
Aluminum Forming Technologies	Hot Rolling Scrap Reduction through Edge Cracking and Surface Defects Control CPS Agreement #13134	0.01	0.5	1.1	2010/b/20

Impact Target	Project	Energy Savings (Tbtu) 2010	Energy Savings (TBtu) 2020	Energy Savings (TBtu) 2030	Year of Intro / Market Selector / Acceleration Period
	Aluminum Subtotal	**0.4**	**13.2**	**12.2**	
Chemicals Processing Technologies	Olefins by High Intensity Oxidation	2.9	43.8	2.6	2008/b/3
	Advances in Process Intensification Through Multifunctional reactor Engineering	0.3	2.5	17.2	2010/c/5
	Using Ionic Liquids in Selective Hydrocarbon Conversion Processes	0.0	1.7	16.3	2012/c/3
	Purification Process for PTA	0.1	2.7	1.6	2008/b/10
	Production and Separation of Fermentation Derived Acetic Acid	0.0	13.8	7.3	2011/b/5
	Millisecond Oxidation of Alkenes	0.7	35.3	16.3	2009/b/7
	Oxidative Dehydrogenation of Ethane Present in Natural Gas to Ethylene	0.0	34.8	26.9	2012/b/4
	Development of Highly Selective Oxidation Catalysts by Atomic Layer Deposition	0.0	24.3	62.6	2014/b/4
	Microchannel Reactor System for Catalytic Hydrogenation	0.3	27.1	19.3	2011/b/6
	Microchannel Reactor System for H_2O_2	0.7	36.0	14.2	2010/b/5
	Enhanced Productivity of Chemical Processes Using Dense Fluidized Beds	1.0	6.1	28.9	2010/c/5
	Low Cost Chemical Feedstocks Using an Improved Energy Efficient NGL Removal Process	1.3	17.3	0.9	2008/b/3
	Development of Advanced membrane Technology Platforms for Hydrocarbon Separations	0.4	3.3	23.9	2008/c/5
	Heat Integrated Distillation Through the Use of Microchannel Technology	0.5	32.6	23.2	2010/b/7
	Chemicals Subtotal	**8.1**	**281.2**	**260.9**	
Paper Pulp Fiber Recycling	Development of Screenable Wax Coating & Water-Based Pressure Sensitive Adhesives (PSAs)	0.1	3.7	7.4	2010/b/10
High Efficiency Pulping	Increasing Yield and Quality of Low-Temperature, Low-Alkali Kraft Cooks with Microwave Pretreatment	0.5	2.7	11.6	2010/c/5
	Integration of MSS-AQ Pulping and BL Gasification	0.4	0.7	1.9	2010/d/10
	Improved Wood Properties through Genetic Manipulation: Syringyl-type lignin	0.0	1.4	3.2	2015/d/10
	Directed Causticizing for BLG in Circulating Fluidized Bed	0.2	0.3	0.9	2010/d/10
	Hemicellulose Extraction and Its Integration in Pulp Production	0.0	0.5	3.0	2015/c/10
	Highly Efficient D-GLU Pulping	0.0	4.2	39.9	2015/b/10
Innovative Wood Drying and Curing	Biological Air Emissions Control	0.0	0.7	6.9	2015/b/10
	HAPs Reduction from Drying & Pressing	0.4	34.1	4.7	2010/a/5
	Development of Renewable Microbial Polyesters for Wood-Plastic Composites	0.3	2.3	11.4	2010/c/10

Impact Target	Project	Energy Savings (Tbtu) 2010	Energy Savings (TBtu) 2020	Energy Savings (TBtu) 2030	Year of Intro / Market Selector / Acceleration Period
	Forest Products Subtotal	**1.8**	**50.4**	**90.8**	
Advanced Melting / Innovative Casting Processes	Energy Saving Melting and Revert Reduction Technology (E-SMARRT)	0.0	37.6	80.3	2014/b/20
Innovative Casting Processes	In-Situ Real Time Monitoring and Control of Mold Making and Filling Processes	0.0	1.9	7.1	2011/b/20
	Metal Casting Total	**0.0**	**39.5**	**87.4**	
Cokeless Ironmaking	Mesabi Nugget Research Project (future efforts)	14.6	74.8	252.2	2009/c/5
	Next Gen Metallic Iron Nodule Technology for EAFs	0.0	7.0	28.4	2010/c/6
Next-Generation Steelmaking	Process to Continuous Melt, Refine, and Cast Steel	0.4	2.6	14.6	2010/c/8
Advanced Steel Process Development	Automated Steel Cleanliness Analysis Tool (ASCAT)	0.1	2.2	0.0	2009/a/7
	Development of Submerged Entry Nozzles that Resist Clogging	0.3	9.4	2.1	2009/b/6
	Inclusion Optimization for Next Generation Steel Products	0.1	4.0	2.0	2009/b/9
	Validation of Hot Strip Mill Model	0.1	1.2	0.2	2009/b/5
	Enrichment of By-products from Pickling Acid Regeneration Plants	0.0	0.2	0.0	2009/b/5
	Characterization of Fatigue and High Strain Rate Deformation	0.1	1.4	0.5	2009/b/8
	Direct Flame Impingement	0.2	1.1	3.8	2009/c/4
	Elimination of Oscillation Marks	0.0	1.4	2.2	2013/b/5
	Criteria of Yield Point Elongation of Surface-Critical Steels	0.0	0.5	0.1	2009/b/5
	Steel Subtotal	**15.8**	**98.8**	**277.5**	
Advanced Industrial Materials	Novel Refractories for High Alkaline Environments - ORNL	0.0	9.6	64.7	2014/b/11
	Advanced Membrane Separation Technologies for Energy Reduction from Industrial Process Streams - ORNL	0.0	16.2	123.8	2014/b/16
	Advanced Wear-Resistant Nanocomposites for Increased Energy Efficiency –Ames	0.0	8.9	29.0	2012/b/13
	Nanocoatings for High-Efficiency Industrial Hydraulic and Tooling Systems – Eaton	0.04	1.7	1.1	2010/b/8
	Hydrogen Transport Membrane Material for Green Ethylene Production – Innovene	0.0	5.9	46.6	2012/c/38
	Aerogel-Based Insulation for Industrial Steam Distribution Systems – Aspen	0.0	48.3	19.1	2011/b/5
	Heirarchical Nanoceramics for Industrial Process Sensors - GE	0.0	3.2	24.5	2012/c/4

Impact Target	Project	Energy Savings (Tbtu) 2010	Energy Savings (TBtu) 2020	Energy Savings (TBtu) 2030	Year of Intro / Market Selector / Acceleration Period
	Industrial Materials Subtotal	**0.04**	**93.7**	**308.7**	
Advanced Sensors	Surface Quality Assured Steel Bar	1.5	37.0	4.1	2009/b/4
	Honeywell PHASED Gas Composition Microanalytics	0.6	6.5	4.8	2009/c/3
Affordable Wireless Technologies	Eaton Wireless Sensor Network	2.1	42.4	4.2	2009/b/4
	GE Distributed Wireless Multi-sensor Technologies	1.9	30.6	2.2	2009/b/3
	Honeywell Wireless	1.3	22.5	1.7	2009/b/3
	Sensors and Automation Subtotal	**7.3**	**138.9**	**17.0**	na
Combustion Technologies	Super Boiler PM/TM Boiler Development and Demonstration	2.0	54.7	27.0	2009/b/10
	Super Boiler 2nd Generation Technology for Watertube Boilers	0.0	122.6	238.4	2012/b/8
	Modular, High Efficiency, Low Emissions Package Boiler	0.0	73.3	142.6	2012/b/8
	Multi-Staged Printed Circuit Boiler for Industrial Applications	0.0	44.1	164.4	2012/b/8
	Advanced Combustion Subtotal	**2.0**	**294.7**	**572.4**	
	Grand Total for 55 R&D Projects	**35.4**	**1010.4**	**1626.9**	

Table H-7: IAC Program - QM Estimation and Summary

Item		2008	2010	2015	2020	2025	2030
	Assessments						
1	New plants affected	300	300	300	300	300	300
2	Cumulative plants affected	300	900	2400	3900	5400	6900
3	Plants retired from count each year			300	300	300	300
4	Cumulative plants retired from counting			300	1800	3300	4800
5	Net plants still affected	300	900	2100	2100	2100	2100
6	Average MMBtu savings per plant assessment	5900	5900	5900	5900	5900	5900
7	Delayed, replicated and spin-off MMBtu savings generated per plant		1475	1475	1475	1475	1475
8	Total TBtu savings from assessments	1.77	6.20	15.49	15.49	15.49	15.49
	Alumni						
9	Number of students graduated in each year		70	70	70	70	70
10	Cumulative number of alumni		70	420	770	1120	1470
11	Percent of alumni staying in energy efficiency		50%	50%	50%	50%	50%
12	Cumulative number of alumni staying in energy efficiency		35	210	385	560	735
13	Alumni retired from count each year		0	0	0	35	35
14	Cumulative alumni retired from counting		0	0	0	175	350
15	Net alumni still counted		35	210	385	385	385
16	Number of assessments conducted per alumnus		4	4	4	4	4
17	Number of alumni assessments annual total		140	840	1540	1540	1540
18	Cumulative alumni conducted assessments		140	2940	9240	16940	24640
19	Alumni assessments retired from count each year				560	1260	1540
20	Cumulative retired alumni assessments				1400	6300	13860
21	Net alumni assessments still counted		140	2940	7840	10640	10780
22	Average MMBtu savings per alumni assessment		5900	5900	5900	5900	5900
23	Delayed, replicated and spin-off MMBtu savings generated per alumni assessment			1475	1475	1475	1475
24	Total TBtu savings from alumni		0.83	20.44	56.37	78.06	79.50
	Web Users						
25	Annual number of unique visitors (initial reach)	30,000	30,000	30,000	30,000	30,000	30,000
26	Number of unique plants using the database	394	394	394	394	394	394
27	Number of unique plants that implement projects	78	78	78	78	78	78
28	Cumulative number of unique plants that implement projects	78	234	624	1014	1404	1794
29	Number of unique plants retiring projects each year		0	78	78	78	78
30	Cumulative number of unique plants retiring projects		0	78	468	858	1248
31	Net number of unique plants with implemented projects	78	234	546	546	546	546
32	Average MMBtu savings per unique plant implementing measures	5900	5900	5900	5900	5900	5900
33	Total TBtu savings from web users (unique plants implementing measures)	0.46	1.38	3.22	3.22	3.22	3.22
34	IAC PROGRAM Total Energy Savings (TBtu)	2.23	8.40	39.15	75.08	96.77	98.21

Table H-8: BestPractices Program – QM Estimation and Summary

		2008	2010	2015	2020	2025	2030
Item	Energy Saving Assessments for Large Plants						
1	New Original Plants Implementing Each Year	200	200	200	200	200	200
2	New Replicating Plants Implementing Each Year	550	550	550	550	550	550
3	Cumulative Original Plants Affected	200	600	1600	2600	3600	4600
4	Cumulative Replicating Plants Affected	550	1650	4400	7150	9900	12650
5	Cumulative Total Plants Affected	750	2250	6000	9750	13500	17250
6	Average Original Identified TBtus Savings per Plant	0.120	0.120	0.120	0.120	0.120	0.120
7	Average Identified TBtus Savings per Replicating Plant	0.120	0.120	0.120	0.120	0.120	0.120
8	Original Implemented TBtus Savings	4.32	12.96	12.96	12.96	12.96	12.96
9	Replicated Implemented TBtus Savings	11.88	35.64	35.64	35.64	35.64	35.64
10	Total New Implemented Energy Savings (TBtu)	16.20	48.60	48.60	48.60	48.60	48.60
11	Persisted Energy Savings (from up to 7 years previous, TBtu)	0.00	48.60	275.40	291.60	291.60	291.60
12	Total Energy Savings from Energy Saving Assessments	16.20	97.20	324.00	340.20	340.20	340.20
	Training Medium Plants						
13	Number of Medium Plants Represented in Initial Reach	1,061	1,061	1,061	1,061	1,061	1,061
14	Number of Medium Unique Plants Taking Action	531	531	531	531	531	531
15	Cumulative Number of Medium Unique Plants Taking Action	531	1,592	4,244	6,897	9,549	12,202
16	Unique Medium Plants Retired from Count Each Year			531	531	531	531
17	Cumulative Number of Medium Plants Retired from Counting			531	3,183	5,836	8,488
18	Net Medium Unique Plants Implementing Savings	531	1,592	3,714	3,714	3,714	3,714
19	Average TBtu Savings per Medium Plant	0.002	0.002	0.002	0.002	0.002	0.002
20	Total Energy Savings from Training with Medium Plants (TBtu)	0.98	2.95	6.87	6.87	6.87	6.87
	Training Large Plants						
21	Number of Large Plants Represented in Initial Reach	136	136	136	136	136	136
22	Number of Large Unique Plants Taking Action	68	68	68	68	68	68
23	Cumulative Number of Large Unique Plants Taking Action	68	204	544	884	1,224	1,564
24	Large Unique Plants Retired from Count Each Year			68	68	68	68
25	Cumulative Large Plants Retired from Counting			68	408	748	1,088
26	Net Large Unique Plants Implementing Savings	68	204	476	476	476	476
27	Average TBtu Savings per Large Plant	0.061	0.061	0.061	0.061	0.061	0.061
28	Total Energy Savings from Training with Large Plants (TBtu)	4.17	12.52	29.20	29.20	29.20	29.20
	Software Medium Plants						
29	Number of Medium U.S. Plants Represented in Initial Research	2,705	2,705	2,705	2,705	2,705	2,705
30	Number of Medium U.S. Plants Taking Action Each Year	541	541	541	541	541	541
31	Cumulative Medium U.S. Plants Taking Action	541	1,623	4,328	7,033	9,738	12,443
32	Medium U.S. Plants Retired from Count Each Year			541	541	541	541
33	Cumulative Medium U.S. Plants Retired from Count			541	3,246	5,951	8,656
34	Net Medium Unique Plants Implementing Savings	541	1,623	3,787	3,787	3,787	3,787
35	Average Energy Savings per Medium U.S. Plant	0.002	0.002	0.002	0.002	0.002	0.002
36	Total Savings from Software Use by Medium U.S. Plants (TBtu)	1.07	3.21	7.48	7.48	7.48	7.48
	Software Large Plants						
37	Number of Large U.S. Plants Represented in Initial Research	383	383	383	383	383	383
38	Number of Large U.S. Plants Taking Action Each Year	77	77	77	77	77	77
39	Cumulative Large U.S. Plants Taking Action	77	230	613	996	1,379	1,762
40	Large U.S. Plants Retired from Count Each Year			77	77	77	77
41	Cumulative Large U.S. Plants Retired from Count			77	460	843	1,226
42	Net Large Unique Plants Implementing Savings	77	230	536	536	536	536
43	Average Energy Savings per Large U.S. Plant (TBtu)	0.064	0.064	0.064	0.064	0.064	0.064
44	Total Savings from Software Use by Large U.S. Plants (TBtu)	4.90	14.70	34.30	34.30	34.30	34.30
	Qualified Specialists Medium Plants						
45	Unique Plants Affected in Each Year	540	540	540	540	540	540
46	Number of Unique Plants Taking Action	270	270	270	270	270	270
47	Cumulative Number of Unique Plants Taking Action	270	810	2,160	3,510	4,860	6,210
48	Unique Plants Retired From Count Each Year			270	270	270	270
49	Cumulative Plants Retired from Counting			270	1,620	2,970	4,320
50	Net Unique Medium Plants Implementing Savings	270	810	1,890	1,890	1,890	1,890
51	Average TBtu Savings per Plant	0.001	0.001	0.001	0.001	0.001	0.001
52	Total Savings from Qualified Specialists (TBtu)	0.37	1.12	2.61	2.61	2.61	2.61
	Qualified Specialists Large Plants						
53	Unique Plants Affected in Each Year	127	127	127	127	127	127
54	Number of Unique Plants Taking Action	64	64	64	64	64	64
55	Cumulative Number of Unique Plants Taking Action	64	191	508	826	1,143	1,461
56	Unique Plants Retired from Count Each Year			64	64	64	64
57	Cumulative Plants Retired from Counting			64	381	699	1,016
58	Net Unique Large Plants Implementing Savings	64	191	445	445	445	445
59	Average TBtu Savings per Plant	0.079	0.079	0.079	0.079	0.079	0.079
60	Total Savings from Qualified Specialists (TBtu)	5.03	15.10	35.23	35.23	35.23	35.23
61	ENERGY TOTAL FOR ALL DELIVERY CHANNELS (TBtu)	32.7	147	440	456	456	456

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